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# How to reduce logistics and inventory costs through lean manufacturing and business process management?

Yi Zhang

Master’s in Applied Management

Supervisor：

Henrique O'Neill, Associated Professor at Department of Marketing, Operations and General Management (IBS)
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## Acknowledgements

I have always aspired to complete my master's degree, which I have been working towards for years and is one of the most important things in my life. I have many years of experience in operations management, which has provided me with a wealth of material for my project research. But I still encountered great challenges in the past year. How to analyze and summarize the problems I encountered using scientific methods? How to allocate time for work, life and research? All of this could not have been done without the support of my family, friends and professors, who provided active help to complete this project.

First of all, I would like to thank my parents, Shiyong Zhang and Jane Ji, my wife, Qin Yang, and my son, Shaoyang Zhang, who have been my strong supporters, and it is because of their support that I have the courage to overcome all difficulties.

Secondly, I would like to thank Mr. Kechen Bo, Chairman of Huaguang Group, and other colleagues of Huaguang Group, for your support in the project and for sharing your experience in the work, which are indispensable and important parts of completing the project.

Finally, I would like to thank my supervisor, Prof. Henrique, who has been a beacon of light in my research process, pointing out the direction of my research and always enthusiastically sharing his knowledge and experience. In addition, he has always followed my research process and provided a lot of useful help and guidance. All this is something I will remember and thank you again.

## Abstract

China's auto sales have been in rapid development for many years and already have a large market scale. Since 2018, the growth rate of China's auto industry has slowed down, and even negative growth has occurred. In recent years, it has also been affected by the impact of COVID-19, price fluctuations of upstream steel materials for automobiles, the international situation and other unstable factors, and the production and sales of each auto plant have declined to different degrees. To consolidate the existing market, each automobile factory has carried out a significant price reduction sale. Auto parts companies, as the upstream of the auto industry, are an important component of the auto value chain and are also affected by the market price cuts. How to improve enterprise management, reduce costs and maintain the competitiveness of the market is an important issue common to the current automotive and parts industry.

HG Group was founded in 1990, is a first-class supplier of Shanghai Volkswagen and T Company, mainly supplying metal body parts, with a total of 1,900 employees and more than 10 branches in China, achieving sales of 2.04 billion RMB in 2020. There is still a lot of room for improvement in management, especially in cost control. In the current severe internal and external environment, the company must think about how to further improve management and reduce costs to ensure market share.

This study primarily focuses on the investigation of lean production and business processes at HG Group's Shanghai factory. The research entails the identification of inventory and logistics cost processes, the completion of process issue identification and analysis, and the formulation of recommendations for inventory improvement and logistics cost reduction. Subsequently, there is evident reduction in inventory data. The present study has demonstrated a proactive role in cost reduction. It successfully amalgamates BPM, SCOR processes, and lean production, culminating in the development of a comprehensive systematic approach, thereby presenting innovative insights for future enterprises.



**Keywords：** Automotive parts, cost reduction, lean manufacturing, business process management, inventory reduction

**JEL Classification:** M00, M19

## Resumo

As vendas de automóveis fabricados na China estão em rápido desenvolvimento e já possuem uma elevada quota de mercado. Todavia, desde 2018, a taxa de crescimento da indústria automobilística da China desacelerou, e até ocorreu um crescimento negativo. Nos últimos anos, a indústria foi também afetada pelo impacto da COVID-19, pelas flutuações a montante dos preços das materiais primas como o aço para automóveis, pela situação internacional e por outros fatores de instabilidade, o que teve impacto na produção e nas vendas de cada marca de automóveis, que diminuíram ainda que em graus distintos. Para consolidar o mercado existente, os fabricantes optaram por uma redução significativa do preço dos automóveis. A montante da indústria automobilística, as empresas fabricantes de componentes são um elemento importante da cadeia de valor automóvel e também são afetadas pelos cortes de preços de venda do produto final. Como melhorar a gestão das empresas, reduzir custos e manter a competitividade no mercado são atualmente questões muito importantes, comuns às indústrias de fabrico de automóveis e de componentes.

O Grupo HG, fundado em 1990, é um fornecedor de primeira linha da Shanghai Volkswagen and T Company, fornecendo principalmente peças de carroçaria metálica. Possui um total de 1.900 funcionários e mais de 10 filiais na China, tendo alcançado vendas de 2,04 bilhões de RMB em 2020. Num ambiente interno e externo que é severo, a empresa deve pensar em como melhorar a gestão e reduzir custos para assegurar a sua presença no mercado.

Este estudo investiga a produção depurada (*lean production*) nos processos de negócios na fábrica de Xangai do Grupo HG. A pesquisa envolve a identificação de processos de gestão de inventário e dos custos logísticos, na análise de constrangimentos dos processos e na formulação de recomendações para melhorar o inventário e reduzir os custos logísticos. O presente estudo demonstrou a capacidade da gestão para contribuir para a evidente redução de custos que foi alcançada. Ao integrar com sucesso BPM, processos SCOR e produção depurada, através de uma abordagem sistemática e abrangente, o estudo apresenta assim contributos inovadores que poderão vr a ser úteis para outras empresas.



**Palavras-chave:** Componentes automóveis, redução de custos, produção depurada, gestão de processos de negócios, redução de inventários

**Classificação JEL:** M00, M19

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## Abbreviation List

| **Abbreviation** | **Full Form** |
|---|---|
| *BPM* | *Business Process Management* |
| *SCOR* | Supply Chain Operations Reference |
| *BPR* | *Business Process Reengineering* |
| *ERP* | *Enterprise Resource Planning* |
| *WMS* | *Warehouse Management System* |
| *SCOR DS* | *Supply Chain Operations Reference - Diagnostic System* |
| *B2C* | *Business to Customers* |
| *B2B* | *Business to Business* |
| MRO | *Maintenance, Repair and Operations* |
| FAW-Volkswagen | *First Automobile Works-Volkswagen* |
| JIT | *Just-In-Time* |

## Glossary

*Lean Production:* A Toyota production model, proposed by several MIT experts, focuses on the value creation process, futher reduce inventory, and eliminates waste in a lean production method.
*Waste:* A Toyota Lean Production concept that references all activities that do not directly create value. The seven wastes common to the lean approach are pending waste, waste handling, defective product waste, movement waste, inventory waste and excessive manufacturing waste.
*Value Strean:* Refers to the entire process of a product or service, from receiving customer information to delivering the product to the customer. There are value-added activities and non-value-added activities in the value stream. The purpose of value chain analysis is to eliminate activities with no added value.
*Quick Die Change:* It is a method to shorten the change time by improving the mold change technology, and ultimately to improve the productivity. Quick die change can change the past high-volume production method and make the equipment more flexible to adapt to the multi-variety and small-volume production method.
*5S:* It is a site management method originated from Japanese companies. It mainly includes the five aspects of organization, tidying, cleaning, sanitation and literacy.
*Inventory control:* It is the control of items and other resources in the production process to maintain a better level of operation, by which process waste and costs can be recuced.
*JIT (Just-In-Time Production):* Introduced in 1953 by Neiichi Ohno, vice president of Toyota, Japan, it is a unique production method created by Toyota Motor Corporation of Japan. JIT emphasizes the elimination of all waste in production, which includes overproduction, movement and waiting time of parts and operators, manufacturing of inferior products, and material storage. JIT means to complete the necessary amount of necessary products in the necessary time and at the lowest cost. (Ke et al., 2019）

# 1. Introduction

This chapter focuses on describing the research problem, understanding the market context and academic background of the research; it presents the main research objectives and indicates the direction of the research; it also explains the specific research methodology, scope and structure of the thesis.

## 1.1 Problem Statement

Currently, China's auto industry is highly competitive, and auto parts companies have entered the era of thin profit. How enterprises can improve management and carry out cost reduction and efficiency improvement has become the key to survival.

According to Feld (2000), there are Five Primary Elements for lean manufacturing: (1) Manufacturing Flow, (2) Organization, (3) Process Control, (4) Metrics and (5) Logistics. Lean production management is an important method of industry consensus, and waste reduction is an important idea of lean production. Toyota's Naiichi Ohno proposed seven major wastes that must be eliminated: (1) waiting waste; (2) handling waste; (3) defective product waste; (4) motion waste; (5) processing waste; (6) inventory waste; and (7) manufacturing excess waste. All these wastes are present in large quantities in manufacturing companies. For the elimination of waste, lean production proposes a systematic solution: value stream analysis, flow, pull, and continuous improvement methods. (Womack et al., 2007）

Business Process Improvement (BPM) is another important method to enhance business management. Business process management is based on the observation that every product a company brings to market is the result of a series of activities. (Weske,2007) Business processes are one of the core assets of an organization. They have a direct impact on the attractiveness of products and services, influence the customer experience and, ultimately, the company's revenue. Processes coordinate corporate resources to meet these external demands and are therefore a key determinant of service costs and operational efficiency. (Kerpedzhiev et al., 2021)

This research uses HG Group as case research, a 30-year-old company that has accumulated extensive management experience and explored lean manufacturing and business process improvement during its rapid growth in the past. How to maintain competitiveness in the current fierce competition in China's auto industry requires the company to pay more attention to management improvement. This research mainly focus on the improvement of lean production and business process management on inventory reduction in HG Group's Shanghai plant and propose targeted solutions to help the company maintain its competitive advantage in the new environment.

### 1.2 Research Question

Based on the current environment faced by HG Group and studied in terms of lean manufacturing and business process improvement, the main research question is:
*"How to reduce logistics and inventory costs through lean manufacturing and business process management?"*

### 1.3 Research Objective

The objective of this research is to identify the major issues affecting inventory and logistics costs by using lean manufacturing and business process management methods, provide recommendations and solutions and evaluate the impact of their implementation on performance.

- Identify significant processes related to inventory and logistics costs through the Supply Chain Operations Reference (SCOR) model.
- Identify and analyze issues affecting inventory and logistics cost processes.
- Proposing recommendations and measures to improve.
- Evaluating the effectiveness of implementation.

### 1.4 Research Method

The current work is an internal project supported by the HG Group, which aims to find paths to reduce logistics and inventory costs and to suggest improvements. Action research methodology is the most appropriate research method in relation to the actual research problem, which requires "the researcher as an active participant in the research situation" (Greener, 2008).

According to Bell et al. (2018), in this type of research, the researcher and the practitioner collaborate to identify and analyze the company’s problems and explore possible solutions. The purpose of this project is to help HG Group find ways to reduce logistics and inventory costs through a lean manufacturing and business process management approach. The company’s management team is the actual conductor of the company and is essential to improve the company’s operations and increase its competitiveness in the market.

According to Dumas et al. (2018), the realized business processes may need to be adjusted when they no longer meet expectations. So BPM lifecycle will be used in this project. The

BPM lifecycle includes phases such as process identification, process discovery, process redesign (also known as process improvement), process realization, and process monitoring. Stakeholders in the BPM lifecycle include management team, process owners, process participants, process methodologists, system engineers, and other positions. The BPM lifecycle also contains a series of methods and tools for identifying processes and managing individual processes.

To facilitate the understanding of the BPM lifecycle stages and to better implement activities such as process identification and analysis, the Reference SCOR model is used.

The SCOR model includes all business activities related to the delivery of a customer's products and services. The model itself encompasses and is built around the seven main management processes of planning, ordering, sourcing, transformation, fulfillment, and return.

### 1.5 Research scope

The research was conducted at HG Group's Shanghai plant, and the survey topic was determined by the research team in communication with the management team. The research project was supported by the management team because the company believes that lean manufacturing and business process improvement activities, in the current domestic and international environment, can help improve the company's performance and market competitiveness.

### 1.6 Research Structure

The main body of this paper consists of the following parts:

Chapter 1: Overview of the thesis, stating the research question, objectives, subsequent methodology and structure of the thesis.

Chapter 2: Literature review, describing the main theoretical concepts, application tools, etc. of this project.

Chapter 3: Methodology, describing the research direction and the project theoretical logic.

Chapter 4: Case Research, describing the case background of this project, identifying the problem, actions, validating the results, and other information.

Chapter 5: Conclusions and Recommendations, describes the findings of the research, answers the research questions, and provides recommendations for future improvements.

## 2. Literature review

This research focus on the relevant areas of lean manufacturing and business process management: lean thinking, flow, pull, quick die change, process management, and inventory control. This chapter includes the relevant theories to provide important support for our research topic; also research the research topics of other scholars in recent years to fully learn from the lessons of previous generations and focus on the changing and adaptive characteristics of management theories in the new era; adequate theoretical research can provide important research methods and rich empirical support for our research.

## 2.1 Business process management（BPM）

BPM is a prescriptive approach for identifying, designing, executing, documenting, realizing, measuring, monitoring and controlling automated and non-automated business processes to achieve targeted outcomes aligned with the organization's strategy. (Bernhard, 2014) Numerous academic experts contend that Business Process Management (BPM) has reached a stage of maturity (van der Aalst, 2013). Its importance is recognized by professionals, and its academic influence is held in high regard. Nevertheless, scholars also raise inquiries about the scope, originality, and rigor of the "research use cases" that BPM delves into, and whether this research is genuinely meaningful or extensive enough. (Recker and Mendling, 2016)

### 2.1.1 The development of BPM

In the 1990s, Davenport and Short, among others, triggered the widespread adoption of Business Process Reengineering (BPR), often conveniently abbreviated to BPR. (Davenport & Short, 1990) By the late 1990s, enthusiasm for BPR waned and many companies terminated their BPR programs. The following reasons emerged from the review:1. Conceptual abuse, where many change initiatives in some organizations were labeled BPR, even for non-core business processes. 2. Excessive radicalism, where some early proponents of BPR, from the beginning, emphasized that re-engineering had to be radical. 3. Immaturity of support, where the technology and tools available at the time were still inadequate.

As society evolved, two key events led to a resurgence of BPR thinking and contributed to the development and establishment of BPM. First, empirical studies have shown that process-based organizations looking to improve processes to increase efficiency and client satisfaction outperform non-process-based organizations. The second important development is the innovation of technology, and many IT achievements have emerged. For example, ERP systems and WMS systems.

The historical perspective above suggests that BPM is a revival of BPR. However, BPR and BPM cannot be equated. While both approaches start with business processes, BPR focusses on planning and organizing processes and is more radical.

### 2.1.2 Contents of BPM

According to Hammer, "Every good process eventually becomes a bad process" unless it is constantly adapted and improved to keep pace with changing customer needs, technology and the competitive landscape.

The BPM lifecycle includes the processes of process identification, process discovery, process redesign (also called process improvement), process realization, and process monitoring. (Dumas et al., 2018) Stakeholders in the BPM lifecycle include management team, process owners, process participants, process methodologists, system engineers, and other positions.

Stakeholders in the BPM lifecycle include management teams, process owners, process participants, process methodologists, system engineers, and other positions.

While these methods and tools are important, the success of BPM in an organization depends on many other factors beyond its scope. In summary, for BPM to be consistently successful, organizations must view BPM as an enterprise capability that is on the same level as other organizational management capabilities such as risk management and performance management. （Dumas et al., 2018）

## 2.2 Standard of Reference Numbers for Supplier Operations (SCOR Model)

The Supply Chain Operations Reference Digital Standard (SCOR DS) provides a range of methods to help organizations achieve rapid improvements. The SCOR model, created by the Supply Chain Council, serves as a strategic planning instrument enabling top-level executives to streamline the intricacies of supply chain management. (Huan et al., 2004) Supply chain management is always evolving, and so are supply chain professionals, who are familiar with the standards and practices, and who drive supply chain development.

SCOR is a powerful tool for supplier management and practice, which is widely accepted. It is highly operational and provides a series of easy-to-use structural frameworks. Moreover, it facilitates business communication with suppliers and improves supply chain management.

The SCOR model sets up a series of business processes oriented to customer needs. The seven main management processes are scheduling, planning, ordering, sourcing, transformation, fulfillment, and return.

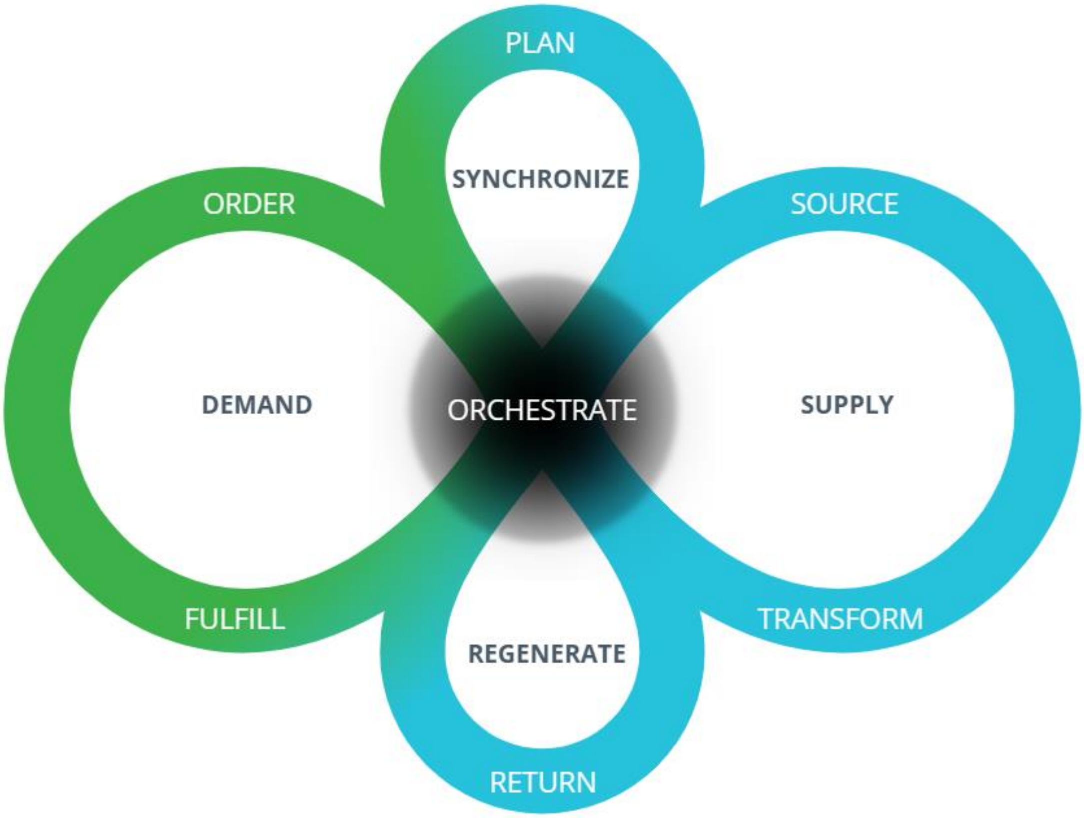


Figure 2.1 SCOR-DS model (ASCM, n.d.)

The graphic of the SCOR-DS model is a bi-infinite diagram that identifies the seven key processes of supply chain management.

SCOR encompasses the entire process of meeting customer service requirements, from receipt of customer orders to completion of customer deliveries. SCOR is not an exhaustive process, and it does not include the sales process.

## 2.3 Lean Manufacturing Theory

After World War II, Eiji Toyoda and Neiichi Ohno of Toyota Motor Corporation in Japan introduced and promoted the concept of lean manufacturing. It was widely promoted in Japan and contributed to the global status of Japanese automobiles and the recovery of the Japanese economy. (Womack et al., 2007)

The lean production method reduces the high cost of manual production and avoids the management rigidity of mass production. The lean production method allows companies to have a large multi-skilled workforce that can skillfully operate a variety of complex machinery and equipment, produce a wider variety of products, and be more flexible in responding to complex changes. Lean has the significant advantage of using less space, fewer workers, and less investment to achieve better operational results. The most important limitation of high-volume production is having a large inventory and not worrying about on-time delivery. It masks a lot of equipment management deficiencies and not strict quality control, and there is no urgency to act immediately. Lean production requires lower inventory, process or even zero inventory, and lean production requires on-time delivery and fast action, as well as the pursuit of perfect quality goals. (Womack et al., 2007)

Value, the key starting point for Lean thinking, and value can only be determined by the end customer. Value is only meaningful when expressed by a specific product with a specific price that meets the customer’s needs for a specific period. Value is created by the producer. From the customer’s standpoint, this is the reason for the producer’s existence. However, for many reasons, it is difficult for producers to define value exactly. Why is the definition of value so difficult? Partly because most producers are willing to do what they know how to do; and partly because customers also only ask for what they have been given. Another reason is that the process of creating value often goes through many companies that define value in their own way, without considering other related ideas. If you take a moment to look at: a good, a service, you begin to see the same problems with defining value in an appropriate way. This requires a new way of talking to customers, but also a new way of consulting with each other and the companies involved in the value stream. Redefining value is very important so that more customers and sales can be found, and soon becomes the key to the success that Lean thinking can have. (Womack et al., 2007)

The value stream is the entire process of realizing a product and service, and the process of value realization. It includes the procurement of raw materials, manufacturing and processing processes, and delivery processes. The complete value stream also includes value-added and non-value-added activities. The aisles of the supermarket shelves are an excellent way to observe the value stream, where multiple value streams can be seen flowing into the hands of the customer. The material product flow reaches its end in the supermarket aisle when the shopper's decision pulls up. The product development process also ends when a new product is introduced. Neiichi Ohno inspired and promoted the Just-In-Time (JIT) system by drawing on the model used in modern supermarkets. (Womack et al., 2007) Value Stream Mapping, also a lean manufacturing methodology, has extended its reach across various industry sectors since its inception and has become the favored method for facilitating and adopting the lean philosophy. (Grewal, 2008, as cited in Romero, 2017)

Flow, the activities required for a product to be designed, sourced and supplied, is continuous. It is a different approach from high-volume production, which often means long waitting time for products and large inventory generation.

Pull, pull is most simply described as the upstream supplier not producing goods or providing services until the downstream customer demands them; but it is quite difficult to do so. The first problem the gentlemen at Toyota noticed with the lean production approach that serves pull is that of large inventories and mass production. Nothing flows. The most effective solutions were shorter die change times and smaller lot sizes. (Womack et al., 2007). After reducing the lot size the same equipment can produce more products and adapt to the needs of multiple varieties; after reducing the lot size the inventory of products can be reduced, the inventory reduction can produce the input of the site, can reduce the use of inventory capital and can reduce quality losses.

Perfection, when an organization begins to precisely define value, identify the entire value stream, and make the steps flow continuously, it can make products that are closest to customer needs, as well as continuously reduce time, space, and cost. To sustain fundamental, continuous improvement, the concept of perfection must first be developed, requiring the application of the four Lean principles of defining value, identifying value streams, flow and pull; and then focusing on eliminating waste. (Womack et al., 2007)

## 2.4 Lean Manufacturing Tools

Quick die change, which originated in Japan in the early 1950s, was created by Shigeo Shingo, a consultant IE engineer at Toyota, who successfully reduced the changeover time of an 800T hood press from 4 hours to 3 minutes after 9 months of improvement at Toyota Motor Corporation in 1969. (Baidu Baike, n.d.) Since the 1980s, when quick die change technology was popularized in western countries, companies around the world have gradually come to a clear understanding that implementing quick die change and thus reducing die change time is one of the key points for implementing lean production in multi-species, small and medium-sized production enterprises. (Cao, 2015)

Line balancing is a method of averaging all processes of production and adjusting the workload so that the process times are similar. Unbalanced operations can lead to excessive stale product and wasteful waiting. There are several basic concepts involved in line balancing, one is the bottleneck process, which is the link in the production process that affects the overall output speed; the second is the idle time, which is the period when there is no work task during the working hours. The third is process balancing, which refers to the adjustment of all processes so that the operating times are similar. There are several important methods to implement production line balancing, one is to optimize and adjust the job content of bottleneck processes; the second is to eliminate unnecessary process content and the third is to merge processes with shorter time.

### 2.5 Cases of Lean Manufacturing

In a research of rapid die change management for multi-species small batch production in TC, Yuanfeng Xie (2020) investigated a stamping production line in TC. There are about 25 kinds of parts in the production line, with a daily production of 80-240 units of each part, and the daily capacity of the production line is 3035 pieces, so the parts need to switch production. The workshop produces in two shifts with 20 hours working time, and the production line produces 3 parts per day, and each die change takes about 2 hours, so the total daily die change is more than 6 hours. Considering the 85% crop rate, the effective time is less than 12 hours per day, and they must work overtime almost every week to catch up with the goods. Also with 25 products per line, producing 3 per day, the average inventory per product is 8.3 days, requiring a large site footprint and huge inventory capital. Together with the management team, the researchers analyzed TC’s problems and developed improvement plans. The first is the internal and external operation time improvement: 1. Decompose the internal operation process and change part of the operation to external operation; 2. Change the serial operation to parallel operation; 3. Change the operation method; through the improvement, the operation time is reduced from 133 minutes to 29 minutes. The next improvement is the automatic die change solution: 1. using automatic clamping instead of manual tightening; 2. fully automatic die change cart technology to automate die removal and feeding; 3. parameter systemization to solidify and store the die and equipment debugging parameters through the system. Through the above solution, the total die change time is reduced to 40 minutes, and the downtime is reduced to 15 minutes, which greatly improves the efficiency of die change. After the improvement, 10 kinds of products were produced every day, and the product inventory was reduced from 8.3 days before to 2.5 days, which reduced the total inventory by 70%; the daily production capacity was increased from 3035 pieces before to 7088 pieces, which increased the capacity by 135%.

Wang Lei (2020) studied pull lean production in Company A. By mapping Company A's current value stream, the research team found that Company A's raw materials took an average of 20 days from procurement to inventory, which was a long cycle time. The research team also found problems with the standardization of production processes in Company A, with a primary production pass rate of 96.1%. After analysis, three main problems were identified, one of which was unclear standard operating documents and unfamiliarity of personnel operations. Secondly, the training and skill evaluation for transferring and new employees were not standardized. Third, the layout of the production line was not standardized, and the process work-in-process backlog caused additional inventory. The research team also found that the production line balance problem in Company A. The bottleneck process of the LM2 product assembly line was 39.6 seconds, and the main process times were below 20 seconds. The bottleneck process affected the overall capacity and caused a lot of wasteful waiting. The process imbalance also led to a backlog of products in the process. The research team combined Company A's actual problems to develop a pull production optimization plan, first mapping current and future values to identify improvement points. Next, line balance, process layout, and process waste were optimized. Finally, the implementation of the pull production method was started. After the introduction of lean production, the quality of the product has improved from 96.1% at the beginning to 98.1% in one pass. The on-time delivery rate also increased from 93.5% at the beginning to 98.42%. Inventory levels improved significantly after the adoption of pull, with the inventory amount dropping from $48.8 million to $38.5 million.

In a study conducted by Li Hongtao (2020) at Changchun Jiwen Automotive Components Company, a research team undertook an investigation into lean production methodologies. Through a combination of interviews and on-site observations, the team identified issues related to inefficient processes, extended inventory cycles, and inadequate equipment maintenance. The research team, aligning with the practical circumstances, established objectives aimed at reducing customer complaints and minimizing mold changeover times. This endeavor encompassed process refinement, improvements in process layout, and the formulation of production maintenance protocols. Ultimately, the research concluded with a noteworthy achievement: a 50% reduction in customer complaints and a reduction of mold changeover times to below 30 minutes.

Zhang Xi's study (2015), focused on the application of pull-based production at Company S, was conducted through methods such as team interviews and case analysis. The research unveiled issues concerning inefficient production processes, imbalanced production lines, and inadequate efficiency. The research team proposed methods to enhance mold efficiency and optimize line balance. Additionally, they established an implementation team and secured support from the company's senior management. Ultimately, a reduction of 60 minutes in mold replacement time was achieved, leading to a 24% increase in production line efficiency.

Hu Yuming's study (2022) explored the application of lean production methods in the manufacturing process of Product H at Company FA. Through on-site case analysis, the research team identified challenges related to the uneven production balance, lengthy production cycles, and high costs of Product H. By means of on-site analysis, the research team proposed approaches such as promoting pull-based production, shortening logistics cycles, and refining processes. Regarding implementation outcomes, there was a 21-second improvement in production cycle time, resulting in an annual production cost reduction of 186,000 units. Moreover, the defect rate decreased by 20.45%.

In conclusion, the theory of Lean Manufacturing has endured that many of the key ideas of Lean Manufacturing are still playing a role in enterprises. Today, the application environment for Lean Manufacturing has changed significantly, with the use of automated equipment becoming more and more widespread and enterprise management systems becoming more and more advanced. In the current environment, many Chinese entrepreneurs continue to experiment and explore in the new internal and external environment. There are also many scholars who are also playing their assignments and actively practicing in their respective fields. This project also focuses on the application and exploration of lean production management methods in the new environment.

# 3. Methodology

This section will focus on the research direction and objectives for action, and the paper will use an action research approach, based on the BPM life cycle (Dumas et. al., 2018), and will use techniques including literature review, surveys, and interviews.

## 3.1 Action Research

As this is an internal company project, the method of conducting the survey is an action research method, as it allows the process of taking action and doing research at the same time.

BPM is a set of management tools for the entire process of each business of a company. It includes the entire process from problem identification to final implementation and validation. According to Dumas et al. (2018), there are seven different stakeholders that are necessary in the BPM lifecycle:

- *Management Team:* The people in charge of the company, the leaders who have a connection to and influence on the process under research.
- *Process Owner:* The person responsible for planning, organizing, and monitoring the process under research, setting performance metrics, leading improvements, and ensuring the resources needed for the proper functioning of their process.
- *Process Participant:* An employee who performs a process daily according to the organization's guidelines.
- *Process Analyst:* Identifies, identifies, analyzes, redesigns, implements, and monitors processes.
- *Process Methodologist:* The expert of the team, providing professional guidance and training to the team members in all phases.
- *System Engineer:* Needs to have a comprehensive understanding of the issues and requirements, and through professional methods and tools, transform them into an effective system suitable for management needs.
- *BPM group:* They are responsible for maintaining knowledge and documentation containing information on how to plan and carry out BPM, ensuring that it is used to achieve the company's strategic goals.

The SCOR model is used in the BPM lifecycle, and the process component of SCOR provides a predefined set of descriptions of the activities that most companies perform to effectively execute their supply chains. The first-level processes include Plan, Order, Source, Transform, fulfillment, and Return.

### 3.1.1 Planning

Level 1 Planning: Outlines the activities involved in developing a normal operating plan for supply.

Level 2 Planning:

P1 Plan Supply Chain: Plan appropriate supply chain management programs, including supply chain capabilities, contracts and specific implementation paths to ensure management needs can be met.

P2 Plan Orders: The process of developing and establishing, as part of the order management process, a course of action that represents a projected allocation to meet the needs of the order.

P3 Plan Source: Establish a course of action that includes the procurement and arrival process of materials, but also the payment activities of the supply chain.

P4 Plan transformation: Develop a course of action for the transformation process, including resource inputs, time requirements, and projected payment needs.

P5 Plan Realization: The process of developing and defining courses of action within a specified period that represent the delivery resources expected to be granted to meet fulfillment requirements.

P6 Plan Returns: A program needs to be developed to meet the needs of returns in both normal and specific situations, and also to include post-return handling and replenishment activities.

### 3.1.2 Order

Level 1 Order: Describes the processes associated with ordering, delivering, receiving and transferring products, services, components and original substances.

Level 2 Order:

（1）Order B2C：Business-related processes between companies and end consumers.

（2）Order B2B：It is a business activity that serves corporate customers and occurs directly with them.

（3）Internal Company Orders：It is a business activity within the company or an associated unit, and also applies the necessary internal processes, contracts and delivery requirements.

### 3.1.3 Purchasing

Level 1 Purchasing: Describes activities related to the procurement, ordering, delivery, receipt, and transfer of products or services.

Level 2 Purchasing:

S1 Strategic Sourcing: Planning a long-term supplier operation approach, focusing on long-term partner concerns and establishing a win-win and risk-sharing approach.

S2 Direct procurement: Processes associated with the procurement of products or services that make up the final product, such as raw materials used in the transformation process to make finished goods and services available for sale to consumers.

S3 Indirect procurement: Processes associated with the procurement of goods and services needed for the continued operation of the organization, but not directly linked to the production of the products and services it sells.

S4 Source Returns: Processes associated with returns and disposal decisions for business reasons, agreements or arrangements such as defects, overages or maintenance or repairs.

### 3.1.4 Transformation

Level 1 Transformation: The transformation process describes activities related to product creation (e.g., production, assembly/disassembly, MRO) and service.

Level 2 Transformation:

T1 Transformation product: It is the process of realizing a product, the process of transforming raw materials and components into a tangible product by means of the corresponding equipment and energy, as originally set.

T2 Transformation services: It is a service process that meets the requirements of the customer through a defined process and the investment of appropriate resources in accordance with the customer’s requirements.

T3 Transformation maintenance, repair and overhaul: The process of improving or restoring an asset to meet its use by investing resources accordingly.

### 3.1.5 Fulfillment

Level 1 Fulfillment: Activities related to the completion of customer order delivery, including some activities related to the delivery process.

Level 2 Fulfillment:

F1 Fulfillment B2C：Business-related processes between the company and the end consumer. Customer orders can be fulfilled through direct shipping or customer pickup.

F2 Fulfillment B2B：It is a direct-to-business fulfillment process where the product is provided directly to the business rather than to the individual, and is also settled between the two businesses.

F3 Fulfillment inside the enterprises：It is the performance activities within the company or associated units, and also applies the necessary internal processes, contracts and delivery requirements.

### 3.1.6 Return

Level 1 Return: It is the process of the return of goods and services from the customer, which requires establishing contact with the customer and doing activities to analyze the causes and responses, as well as considering the disposal and replenishment after the return.

Level 2 Return:

R1 Returned products: Processes related to the receipt, diagnosis, disposal and location of returned products.

R2 Return service: The processes associated with the receipt, diagnosis and activities required to return a service. Service returns can be handled digitally, face-to-face (e.g., formal meetings or requests), or through other communication channels.

R3 Return for repair: The processes associated with the Maintenance, Repair and Overhaul process set distinguish themselves by returning identical product units to the original customer of return and verifying them by product serial number or other unit ID method.

## 3.2 Investigation Phase

This section will establish the necessary investigation process to ensure the effectiveness of the related activities. The BPM lifecycle will be used in the project, including the processes of identification, discovery, redesign, implementation, monitoring, etc.

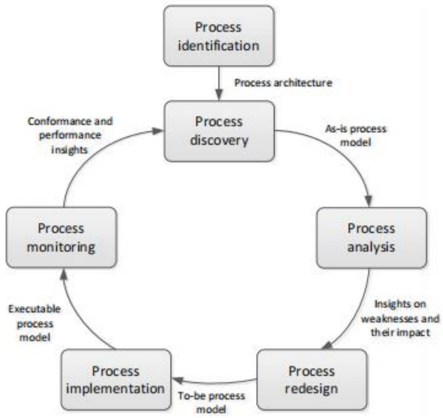


Figure 3.1 BPM Life Cycle (Source : Dumas et al., 2018)

The research work at HG Group will follow six processes in the BPM lifecycle（Fig.3.1):

Phase 1: Process identification, in which the researcher and the management team work together to identify the processes necessary to fulfill customer orders, understand the sequence of these processes and their interconnectedness. The process identification checklist is refined through stakeholder communication.

Phase 2: Process discovery, in which the researcher records the current state of the process, conducts interviews with stakeholders, and forms a process model.

Phase 3: Process analysis, in which the results of the interviews are statistically analyzed, the process content is analyzed, problems are defined and ranked in a combination of qualitative and quantitative ways, and the costs and returns of the inputs are considered.

Phase 4: Process redesign, in which the researcher and management team discuss the problem solution and propose a new process model.

Phase 5: Process implementation, in which the researcher and the management team discuss and determine the resources and implementation steps for the new process model, and finally organize the resources and achieve the design expectations.

Phase 6: Process monitoring, where the new process implementation process is monitored and implementation data is tallied. It also compares the improvement results and provides recommendations for the improvement of the new process.

# 4. Case Study

## 4.1 Introduction

In order to better understand the background of this research, firstly, the company's history and size was studied, secondly, the company's main customers were researched, and thirdly, information about the company's main suppliers was obtained. Then all the steps mentioned in the previous chapters were followed.

## 4.2 HG Group

HG Group was established in December 1990 (Figure 4.1), the initial stage of creation for the Shanghai Volkswagen Corporation Santana model roof trim, glass guide and other metal parts of the localization of supporting, and later successively into the FAW-Volkswagen Corporation, Dragon Corporation, has become China's three major car base of metal parts production supporting enterprises.

In 1995, the group started to cooperate with Japan INOAC Corporation, through which it has established more than ten subsidiaries and HG Group Technical Research Institute. It is mainly responsible to produce rolled parts for passenger cars and the development and production of interior and exterior body trim parts.


Figure 4.1 History of HG Group (Source: HG Group)

HG Group Co., Ltd. has a total production area of 300,000 square meters, 1,900 employees and fixed assets of 900 million RMB. 2021 is expected to achieve sales of 2 billion RMB.


Figure 4.2 HG Group System Certificate (Source: HG Group)

In 2002, the group company was established, and through the group structure, the management of all subsidiaries and branches were unified. ISO/TS16949 quality management system certification and ISO14001 environmental management system certification were passed respectively in 2003 and 2007 (Figure 4.2).

HG Group’s main products are structural body parts, which are the core components of the body (Figure 4.3). The main materials are steel plates and aluminum materials. The quality of the parts is very demanding. Thanks to the quality system capability accumulated over the years, the quality performance on the client side is excellent.

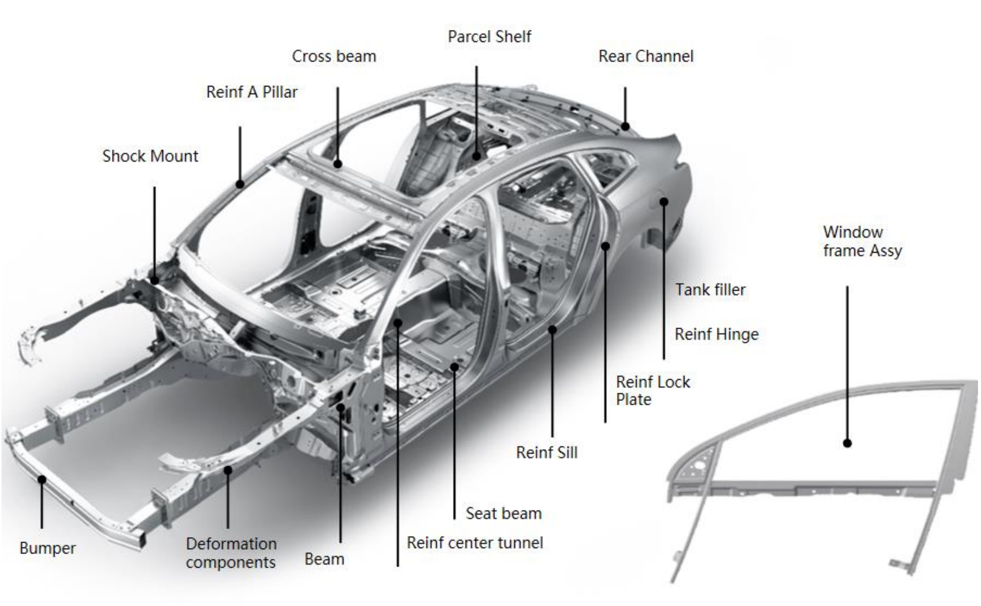


Figure 4.3 HG Group product samples (Source: HG Group)

### 4.2.1 Major Customers

HG Group's sales were $1.6 billion in 2022 and are expected to reach $2 billion in 2023. This is mainly due to the growth in performance of major customers. The following is a breakdown of HG Group's major customers by percentage (Figure 4.4).

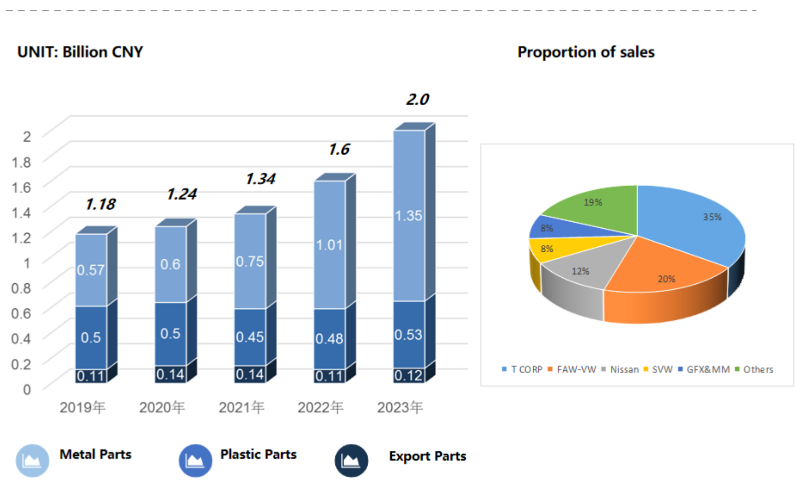


Figure 4.4 HG Group customer sales share (Source: HG Group

#### 4.2.1.1 SAIC Volkswagen

SAIC Volkswagen is one of the important customers that HG Group cooperated with earlier. It is a joint venture between SAIC Group and Volkswagen Group, signed in October 1984, and is one of the oldest automotive joint ventures in China. The company is headquartered in Anting, Shanghai, with six production bases and one technical center nationwide, with a cumulative output of over 26 million vehicles and nearly 30,000 employees.

HG Group mainly supports the body metal parts business of SAIC Volkswagen Touareg, Kolok and Tuoyue, etc., with a supply distance of 150 km.

#### 4.2.1.2 T Company

HG Group will be the first Chinese supplier of body parts to T in 2019, the first wholly foreign-owned vehicle manufacturer in China and has been in the limelight since the establishment of its Shanghai Super Factory, which is over 1,200 mu in size and currently producing two models, M3 and MY, with an annual production capacity of 1 million sets.

HG Group Shanghai factory was established in 2020, is the first batch of territorial suppliers of T, and T supply distance is less than 5 km. It currently adopts the JIT supply method and is also the subject of this research.

### 4.2.2 Major Suppliers

Baoshan Iron & Steel is a leading steel company in China and a leading international steel company, and a Fortune 500 company.

Baosteel was founded by Shanghai Bao Steel Group in February 2000 and was listed on the Shanghai Stock Exchange in December of the same year. Ba Steel has several manufacturing bases in China and a complete range of carbon steel products. The production of auto plates and crude steel is leading in the world.

Baoshan Iron & Steel is one of the important raw material suppliers of HG Group, which is usually purchased and unrolled by the traders appointed by the vehicle manufacturers and then supplied to the parts manufacturers.

## 4.3 Process Identification

The process identification is an important activity for the smooth implementation of the subsequent work. Firstly, it is important to focus on the theme of the paper "How to reduce logistics and inventory costs through lean manufacturing and business process management". Secondly, it was based on the business process characteristics of the HG Group. To this end, this research worked with the HG Group management team to identify the processes necessary to fulfill customer orders, and to determine the sequence of these processes and their interconnectedness. The final decision was made to use the planning, sourcing, transformation, and fulfillment processes in the BPM lifecycle with reference to the Supply Chain Operations Reference SCOR model.

## 4.4 Discoveries

This section focuses on understanding HG Group's process for meeting customer deliverables. The specifics of the six processes will be described in detail to support the next step of the process analysis by means of interactions with relevant stakeholders and on-site observation records, assisted by the Bizagi tool.

### 4.4.1 Plan

Level 1： Describes the activities associated with meeting customer delivery. Includes receiving information from customers, analyzing resource capabilities, and determining resource requirements. Develops a feasible course of action and plan.

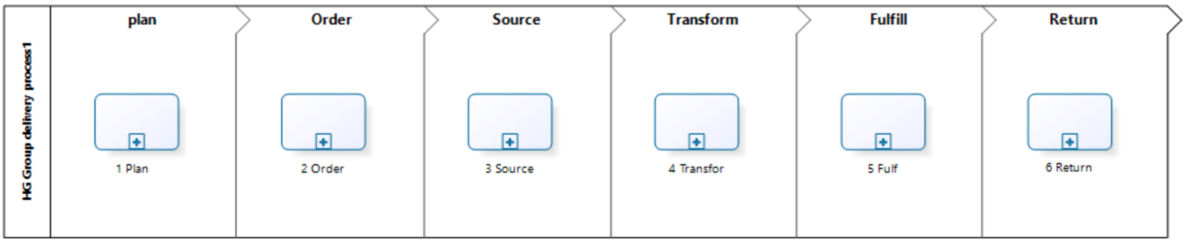


Figure 4.5 The process of Level 1 plan

Level 2：Level 2 identifies and establishes the planned procurement process (Figure 4.6), as this segment affects raw material inventory and logistics costs, and is the subject of this research.

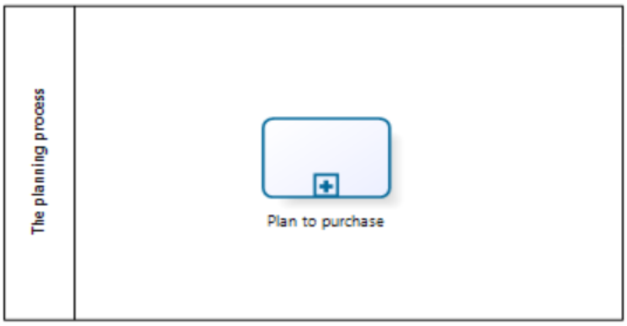


Figure 4.6 Level 2 planned procurement process

Level 3:

- Planned Procurement

Planned procurement, first of all, is the process of organizing the identification, prioritization and consideration of the overall and component parts, based on the customer’s annual or monthly plan, of all sources of demand for products or services in the supply chain (HG Group’s procurement needs are mainly for steel). Then the process of identifying initial procurement options within a defined period and organizing the process of reviewing the options to balance and commit procurement supply resources to meet customer order requirements (Figure 4.7). The process of realigning the source allocation plan and demand plan to meet business and supply chain objectives by changing the source allocation activities, demand plan and resource plan as needed (this research focuses on the steel supply cycle, which is currently 1 time per week for HG Group). Finally the process of developing and defining a course of action within a defined period, i.e., anticipating appropriated resources to meet source demand (HG Group is currently invoiced for steel payments for 60 days).

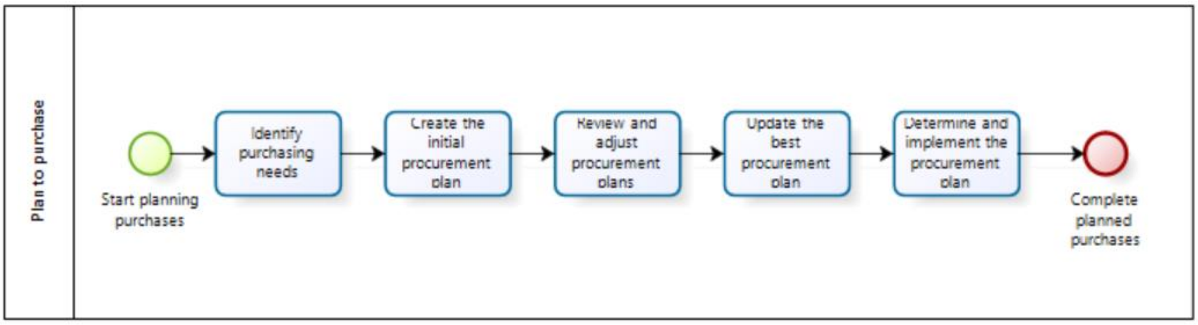

Figure 4.7 Level 3 planned procurement process

### 4.4.2 Transformation

Level 1: Level 1 processes describe the processes associated with the final realization of a product or service, this time focusing on the transformation of raw materials, ingredients, and components into tangible products through labor, machinery, tools, and recipes. (Annex B)

Level 2: The Level 2 process examines the execution process that includes planning and managing the activities required to create the product. It mainly includes the transformation of the product according to the production plan, the necessary manufacturing technology, and the procurement of the required resources to complete the product. This process also includes sequencing, as well as setting and running any criteria based on the plant layout. Closely related to this study are the scheduling production process, the quick die change process, and the line sequencing process.

Level 3

- Arrangement of production process (Annex C)

The first step in scheduling production activities is to confirm whether the engineering process information is correct (this research focuses on whether the steel type and size meet the requirements) and to assess the production capacity; the second step is to schedule the production plan, which mainly includes personnel, equipment, materials, apparatus preparation, also includes information on production lot size, inventory requirements, etc. (This research focuses on the information on economic lot size and inventory requirements. The batch arrangement is 10,000 sets, with a daily delivery of 2,000 sets and 5 days of inventory for one production run.) The production schedule is based on the production schedule; finally, the raw materials are equipped and distributed as required by the production schedule to move to the next stage.

- Quick die change process

Quick die change is to shorten the mold change time by improving the mold change technology, and finally to achieve the flexibility of the equipment. Activities that allow one machine to produce multiple products. The ability to switch quickly is becoming increasingly important in the current market.

(HG Group's current equipment is mainly large, automated equipment, and the process of switching involves adjusting many components, including mainly the mold and mold clamping, the product end picker, the air and circuit systems, and the process parameters. (The current mold change time is about 45 minutes each time, which is also an important factor limiting small product batches and reducing inventory). Quick die change is a highly specialized task, with critical safety and quality implications involved in the changeover process and requires experienced personnel to be responsible for its implementation. Quick die change time improvements include observing the process, distinguishing between internal and external operations, internal to external analysis, reducing internal operations, reducing external operations, and standardization improvements. (Annex D)

- Production line sequencing process

Production line sequencing is the planning of the sequential scheme of product making according to the path set by the process. The production planner releases the quantity of demanded products, the logistics distributes materials to the site according to the demanded quotas, the operator uses the materials according to the specified process, and the production process also considers the control of process defects. Production line sequencing has a great impact on the efficiency of the production process, too much inventory, too long logistics will increase the investment of resources.

Process layout has a large impact on logistics costs and is the focus of this research. Currently HG Group has two workshops for production and logistics. According to Figure 4.8, during the stamping process parts have two transfer processes from workshop 1 to workshop 2, each transfer takes 10 minutes, and the stamping workshop has a capacity of 10,000 pieces per day, 80 pieces per standard box, and 125 boxes per day for transfer. Each time 2 boxes are transferred; the total time is 10.4 hours. Considering that the welding workshop must double the workload, 2 forklift workers are needed for the transfer of stamping parts.

| The process | Number of parts | Number of packages | Number of transfer boxes | Number of boxes per time | Number of trips | Number of transshipment trips（Min） | Total of（Hour） | Input of resources |
|---|---|---|---|---|---|---|---|---|
| Transfer to Workshop 2 | 10000 | 80 | 125 | 2 | 62.5 | 10 | 10.4 | 1 forklift and 1 worker |
| Turn back to workshop 1 | 10000 | 80 | 125 | 2 | 62.5 | 10 | 10.4 | 1 forklift and 1 worker |

Figure 4.8 Process layout data measurement

### 4.4.3 Fulfillment

The Level 1 process is the entire process of meeting customer order delivery and also includes other activities related to delivery, such as packaging, shipping, and invoicing processes. HG Group is currently fulfilling a B2B approach, which is a commercially related process between two businesses, with the product shipped directly to the business customer. (Annex E)

Level 2: Level 2 focuses on the process of periodic deliveries, where the customer’s pickup method has a significant impact on both inventory quantities and site occupancy. The main categories are periodic delivery and JIT delivery methods.

Level 3

- JIT (Just in time) delivery method

Customer JIT delivery method has improved the requirements of suppliers, firstly, the delivery punctuality requirements are increased, JIT way to receive customer orders 2 hours to complete the picking, order verification, loading and delivery to the client. Secondly, the accuracy of delivery, JIT way delivery method in the client only 2 hours of the product, any quality problems may lead to the risk of customers stopping the line. Customer JIT delivery method on the supplier cost reduction, JIT way delivery frequency of 2 hours once, the supplier side of the inventory only need to ensure 1-2 days to meet the delivery, a great reduction in inventory costs, site utilization has also been significantly improved.

Customer JIT supply method for supplier management promotion, JIT production is a manufacturing concept based on the planned elimination of all waste and continuous improvement of productivity. The key elements of Just-In-Time are having only the required inventory when needed; improving quality to zero defects; reducing lead times by reducing lot sizes; and the ability to advance continuous improvement at suppliers, continually upgrading and revising the business itself, and completing these activities at the lowest cost. (HG Group currently has both JIT and order-based delivery methods that currently exist depending on customer requirements.)

### 4.5 Process Analysis

The previous section described the important process of fulfilling customer orders at HG Group and expanded on the activities related to inventory activities. This section focuses on the results of the previous investigation and analyzes the problems that exist. A combination of qualitative and quantitative analysis is mainly used.

#### 4.5.1 Qualitative Data Analysis

Stakeholder interviews and field observations were used in the question collection process, and the data collected were disaggregated and counted to support the use of qualitative and quantitative analysis. (Annex A)

Problem 1: Excessive waste in procurement

Priority:

Process: Planning

Description: 1 raw material supply per week, 1 supply in larger quantities, resulting in increased raw material inventory and also increased site occupancy.

Data and assumptions: Assuming that the frequency of raw material supply increases to 1 time per 2 days, the number of raw material occupancy decreases from 10,000 to 4,000 units, the average cost of raw material is 4 euros, totaling 15 products, the expected reduction in occupancy is 360,000 euros, and the expected annualized cost of capital is 5%. Expected to occupy 2 ㎡ per 300 units, expected to occupy 600 ㎡ less, expected to rent 5 euros/㎡ per month.

Qualitative impact: Larger production lots lead to production inventory backlog, which directly leads to increased logistics costs and rework costs, and indirectly leads to an increase in inventory capital and a decrease in site utilization.

Quantitative impact：360000*5%+600*5*12=54000 Euros/year

Problem 2: Creating too much waste

Priority:

Process: Manufacturing

Description: Excessive stamping production batches lead to an increase in products in stock and occupy a large amount of space.

Data and Assumptions: Assuming a reduction in production volume from 10,000 to 4,000 units per batch and an average product unit price of 7 Euros for a total of 15 products, the expected reduction in occupied capital is 630,000 Euros, with an expected annualized capital cost of 5%. It is expected that each 300 units occupy 5 m², the expected reduction in occupied space is 1500 m², and the expected monthly rent is 5 Euros/m2.

Qualitative impact: Larger production lots lead to production inventory backlog, which directly leads to increased logistics costs and rework costs, and indirectly leads to an increase in inventory capital and a decrease in site utilization.

Quantitative impact: 630,000 * 5% + 1500 * 6 * 12 = 121,500 Euros/year

Problem 3: Creating handling waste

Priority:

Process: Manufacturing

Description: Poor process layout increases the process of transferring items, which ultimately leads to increased costs related to logistics.

Data and Assumptions: Assuming the elimination of cross-workshop transfers, a double shift would reduce 2 forklifts (€30,000 each, amortized over 5 years) and 2 forklift operators (€1,500/month per forklift operator).

Qualitative impact: Poor layout increases the workload of item transfer, which directly leads to an increase in personnel and equipment, and indirectly leads to an increase in inventory capital and a decrease in space utilization.

Quantitative impact: 2*30,000/5+2*1500*12=48,000 Euros/year

Problem 4: Inventory waste

Priority:

Process: Delivery

Description: Some products are picked up by customers on a batch basis every 3 days, resulting in an increase in finished goods inventory and taking up a lot of space.

Data and Assumptions: Assuming customers pick up products on a JIT basis, finished goods inventory can be reduced from 6,000 sets to 2,000 sets.

The average product unit price is 7 Euros for a total of 5 products, which is expected to reduce the occupied capital by 140,000 Euros, and the expected annualized capital cost is 5%.

It is expected that every 300 units occupy 5 ㎡, and it is expected to occupy 330 ㎡ less, and it is expected to rent 5 Euros/㎡ per month.

Qualitative impact: Inventory backlog, directly leading to increased logistics costs and rework costs, indirectly leading to an increase in inventory capital and a decrease in site utilization.

Quantitative impact : 140,000 * 5% + 330 * 5 * 12 = 26,800 Euros/year

### 4.5.2 Quantitative Process Analysis

Quantitative analysis is a very important tool to make up for the lack of qualitative analysis in terms of data performance, which can be used to reflect the effects of the implementation through quantitative data and better facilitate the management team to make the right decisions.

As mentioned earlier, the goal of this project was to analyze the changes in logistics and inventory cost reduction caused by lean manufacturing and business process management changes. Therefore, the focus was on raw material inventory impact, manufacturing process impact, and delivery process impact. The results of the implementation are also mainly in the areas of inventory capital, storage costs, and handling costs (Table 4.1).

**Table 4.1** Cost calculation table

| The process | Name of fee | Resource cost description | Other Cost descriptions | Total annual expenses （€） |
|---|---|---|---|---|
| Buying too much waste | Loss of inventory capital | It occupies 360,000 euros and is expected to have an annualized cost of 5%. | | 18000 |
| | Loss of site rent | Covers an area of 600 ㎡, the monthly rent is 5 euros /㎡. | | 36000 |
| | | | | **54000** |

| The process | Name of fee | Resource cost description | Other Cost descriptions | Total annual expenses（€） |
|---|---|---|---|---|
| Create too much waste | Loss of inventory capital | The capital occupied is 630,000 euros and the annualized cost is 5%. | | 31500 |
| | Loss of site rent | Covers an area of 1500㎡, the monthly rent is 5 euros /㎡. | | 90000 |

**121500**

| The process | Name of fee | Resource cost description | Other Cost descriptions | Total annual expenses（€） |
|---|---|---|---|---|
| Manufacturing handling waste | Forklift equipment loss | Reduction of 2 forklifts at €30,000 each, amortized over 5 years | | 12000 |
| | Loss of forklift worker | Reduction of 2 forklift workers, each forklift worker 1500 euros/month | | 36000 |

**48000**

| The process | Name of fee | Resource cost description | Other Cost descriptions | Total annual expenses（€） |
|---|---|---|---|---|
| Waste of stock | Loss of inventory capital | The capital occupied is 140,000 euros, and the annualized cost is 5%. | | 7000 |
| | Loss of site rent | Covers an area of 330㎡, the monthly rent is 5 euros /㎡. | | 19800 |

**26800**

## 4.6 Process Design

The business process identification, process discovery, and qualitative and quantitative analysis of the problems led to reflection and exploration of solutions to the range of problems identified, which then led to the consideration of process redesign. This chapter discusses methodological processes for rethinking and reorganizing operations to help problem solving and ongoing support and monitoring to make them work better.

### 4.6.1 Excessive Procurement Waste

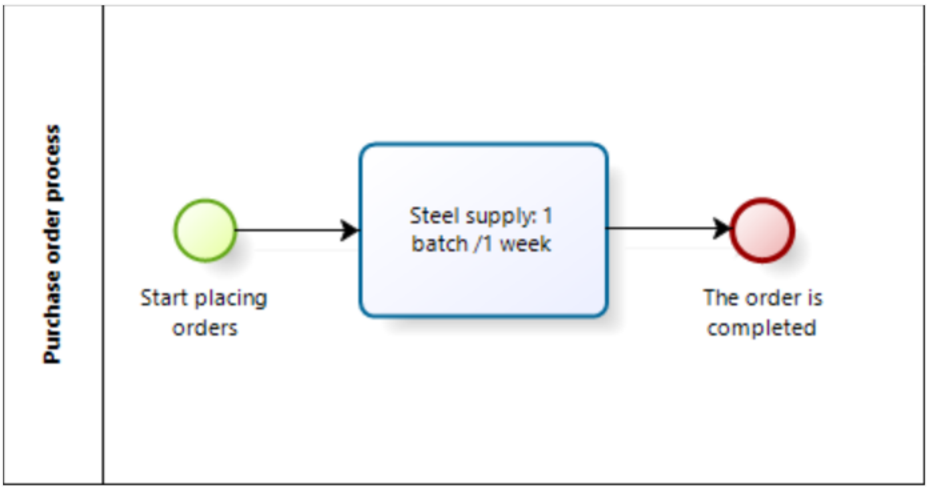


Figure 4.9 Pre-change planning procurement process

First, the purchaser receives the designated customer plan (2000 sets per day, 5 days a week) and the purchaser begins to place a purchase order to the designated supplier, which requires 1 delivery per week (2000*5=10000 sets). The product currently supplied has 15 parts, 10,000 sets of each part, for a total of 150,000 sets of inventories generated (Figure 4.9).

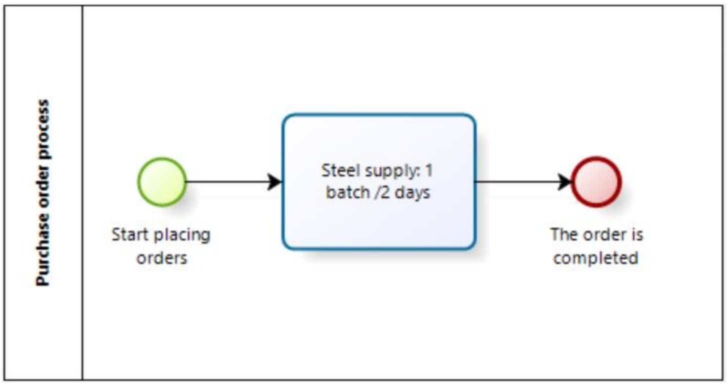


Figure 4.10 Modified plan procurement process.

The change of purchase order needs the support of suppliers, because reducing the number of deliveries per batch also increases the delivery frequency of suppliers and increases the logistics cost of suppliers (Figure 4.10). Of course, the increased logistics costs need to be solved by a better collocation method, which is gradually adapted to the collocation supply method after the supplier’s ability has been improved. Since smaller deliveries would make it more difficult to assemble and, in many cases, increase logistics costs, the once-a-day delivery option was decided upon after measuring. After changing the process, the purchaser received the designated customer plan (2000 sets per day, 5 days a week), the purchaser began to send purchase orders to the designated supplier, the order requires delivery once every 2 days (2000 * 2 = 4000 sets). The current supply of products are 15 parts, 4000 sets of each part, a total of 60000 sets of inventory, compared to the previous reduction of 90,000 sets of inventory. It is expected that each 300 units occupies 2 ㎡, and it is expected that the area is reduced by 600 ㎡. The supplier is also requested to consider reasonable carpool transportation and not to add additional freight costs.

### 4.6.2 Creating excessive waste

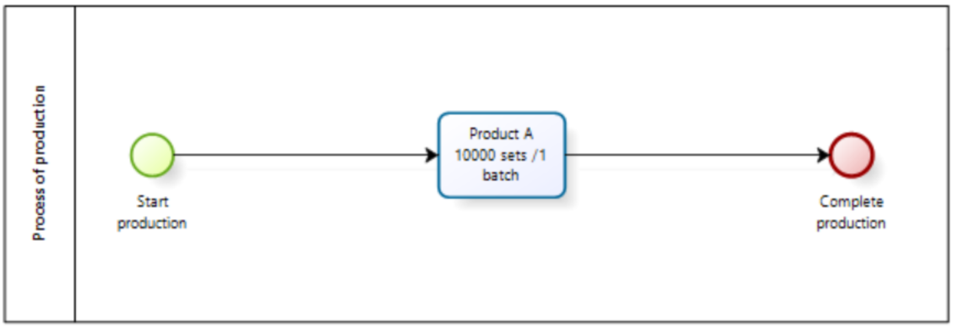


Figure 4.11 Pre-change production planning process

First, the production capacity of stamping equipment is 10,000 sets per day, so the production arrangement for each batch of a product is also 10,000 sets, so that the die can be changed once a day and the time of die change can be saved. The customer plans to produce 2,000 sets per day, 5 days a week, so each stamping machine can produce 5 products in a cycle of 5 days. Currently there are 3 stamping machines, which can produce 15 products in total. The average inventory of each product is 10,000 sets, and each 300 sets of products occupies 5 ㎡, so the total area of 15 products is 2500 ㎡ (Figure.4.11).

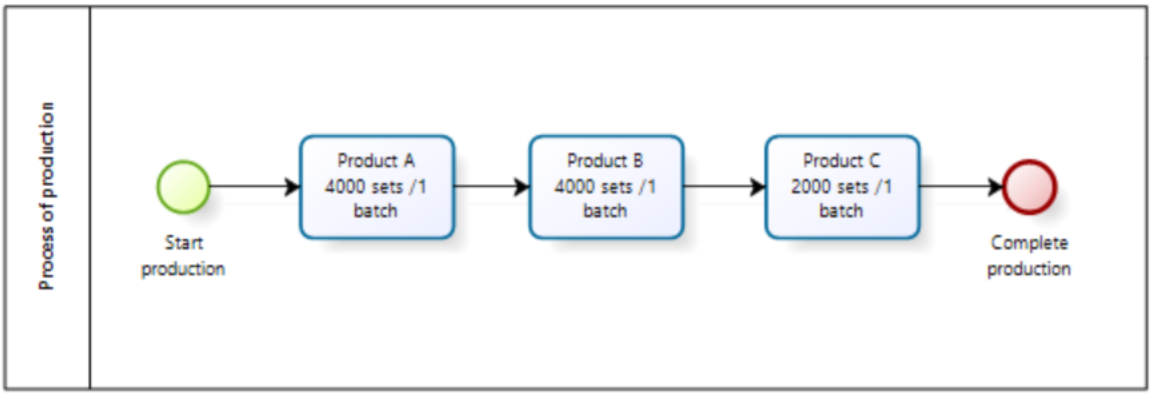


Figure 4.12 Modified production planning process.

The changed production volume per batch is reduced from 10,000 to 4,000 units for a total of 15 products, for a total reduction of 90,000 sets of inventories. It is expected that each 300 sets occupy 5 ㎡, and it is expected to occupy 1500 ㎡ less. After changing the economic batch, the number of mold changes is now increased to 2.5 times per day from 1 time per day before. Here also the efficiency of mold change has been improved, from 45 minutes each time before to about 10 minutes each time now, overall the mold change time has not increased, so there is no loss of daily production efficiency (Figure 4.12).

### 4.6.3 Manufacturing Handling Waste

Firstly, the production workshop and logistics workshop receive the production instruction, the logistics forklift workers transfer the raw materials from workshop 1 to the stamping production line in workshop 2, the stamping workers load the produced stamping process parts into the standard apparatus, and the logistics forklift workers transfer the stamping process parts from workshop 2 to the semi-finished product warehouse in workshop 1. Then the welding workshop receives the production instruction, the logistics forklift workers transfer the stamping process parts from workshop 1 to the welding production line in workshop 2 again, the welding workers load the finished products into the standard apparatus, and the logistics forklift workers transfer the finished products from workshop 2 to the finished products warehouse in workshop 1, thus completing the whole production process. During this period, there are two transfer processes from workshop 1 to workshop 2, and each transfer takes 10 minutes. The daily capacity of stamping workshop is 10,000 pieces, and each standard box is 80 pieces, so 125 boxes are transferred every day. The total time for each transfer is 10.4 hours for 2 boxes (Figure 4.13).

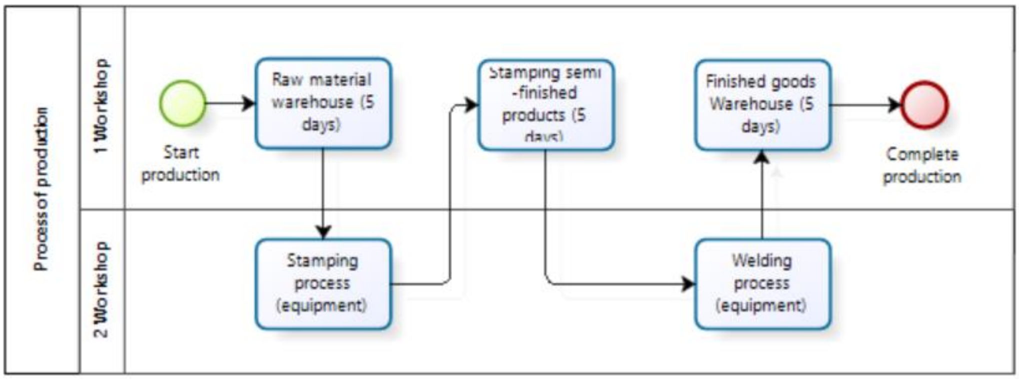


Figure 4.13 Pre-change manufacturing handling process.

Considering that the welding workshop has to double the workload, 2 forklift workers are needed for the transfer of stamping parts.

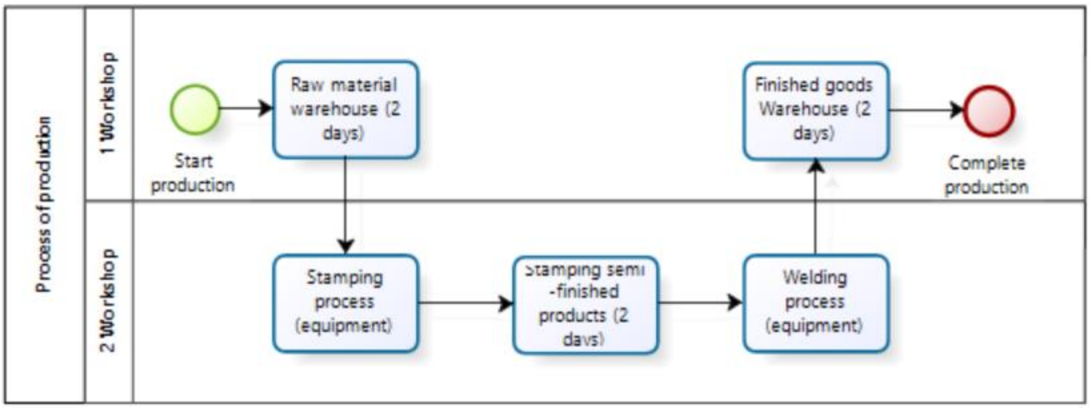


Figure 4.14 Modified manufacturing handling process.

After changing the layout, the stamping inventory area was moved to the middle area of the stamping and welding equipment after reducing the stamping inventory from 5 days to 2 days through improvement. By eliminating cross-shop transfers, the distance was reduced to less than 5 minutes per transfer, and 2 forklifts and 2 forklift operators could be reduced on double shifts (Figure 4.14).

### 4.6.4 Inventory Waste

First, the delivery order from the customer was received, and according to the previous contract, the customer will deliver 2000 sets per day according to the delivery every 3 days, and the finished product inventory needs to be set at 6000 sets. At present, there are 6 products in total, totaling 36,000 sets of inventory, and it is expected that each 300 sets will occupy 5 ㎡, totaling 600 ㎡. The inventory backlog directly leads to increased logistics and rework costs, and indirectly leads to increased inventory funds and decreased site utilization Figure 4.15).

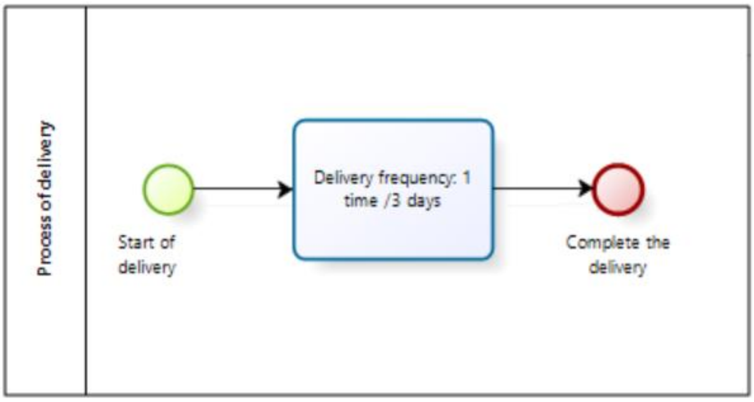


Figure 4.15 Pre-change customer delivery order.

Because of the increase of the client's site due to the large volume of delivery, after communication with the customer, the JIT method of delivery was decided to be accepted, and the frequency of product delivery was adjusted to once every 2 hours. The finished product inventory can be reduced from 6,000 sets to 2,000 sets, and it is expected that the area will be reduced by 330 ㎡ (Figure 4.16).

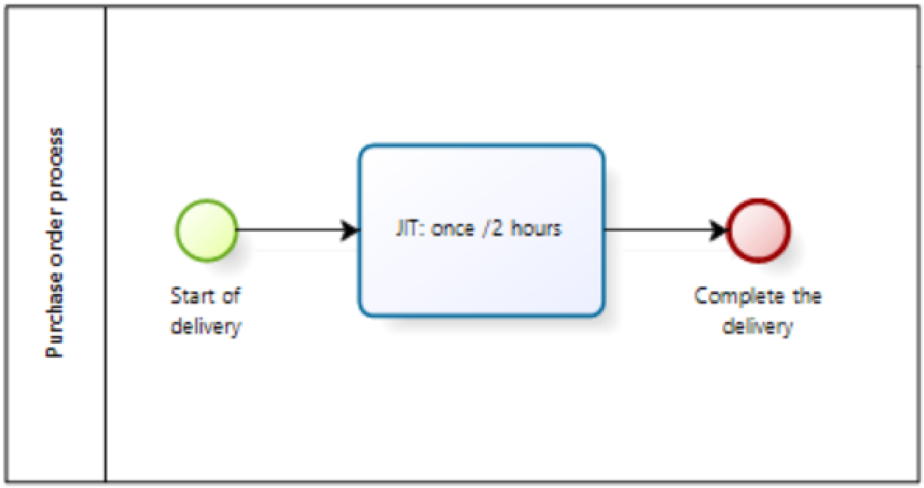

Figure 4.16 Modified customer delivery order.

### 4.7 Process Implementation

During this phase, the changes required to move from existing processes to future processes are prepared and implemented.

The researchers and management team formed groups at the beginning of the project phase, all with a clear division of labor, and proposed goals and specific implementation paths. The causes of specific problems were fully discussed during the process analysis phase, and stakeholders were invited to discuss the feasibility of improvement methods together. All solution measures and process changes were discussed with the management team, and the company's decision was approved and implemented by the management team in the first place.

The raw material procurement lot changes involved coordination with suppliers, which was a difficult task to accomplish. The researchers quickly received support from the management team and key leaders, and the implementation was completed from suppliers to within the plant in 2 weeks.

The changes in production economic lot size and process layout were aimed at internal management improvements, and guidance was received from the process and planning departments in advance of planning in order to successfully complete the improvement program. During the implementation period, there were also issues related to financial support for equipment modification and new equipment investment, which were also supported and resolved by the management team.

More practical problems were encountered during the process realization, during which the support of the management team was indispensable and the researchers had to overcome difficulties.

### 4.8 Process monitoring and control

The process monitoring and control phase is the validation of all previous analysis processes and resolution measures. All measures and changes need to be continuously tracked by the management team to ensure their effective implementation.

Over the past few months, there has been a significant improvement in the inventory situation within the company and a major boost in team morale, which is ultimately reflected in the company's key operating figures.

According to Figure 4.17, before the improvement of the program in August 2022 - October 2023, the inventory days for raw materials, semi-finished and finished goods were at 14 days and the inventory capital was at €2.7 million.

During the November 2022 - March 2023 program, there was a significant downward trend in inventory days and capital.

From April 2023 to May 2023, the program was basically completed, and the inventory days for raw materials, semi-finished and finished products were at 6 days, and the inventory capital was at 1.08 million Euros.

The above data shows the changes in logistics and inventory cost reduction caused by lean manufacturing and business process management changes. For sure, the final direct and indirect economic benefits generated need to be further accounted for, but the current results are a recognition for the team. (Annex F)

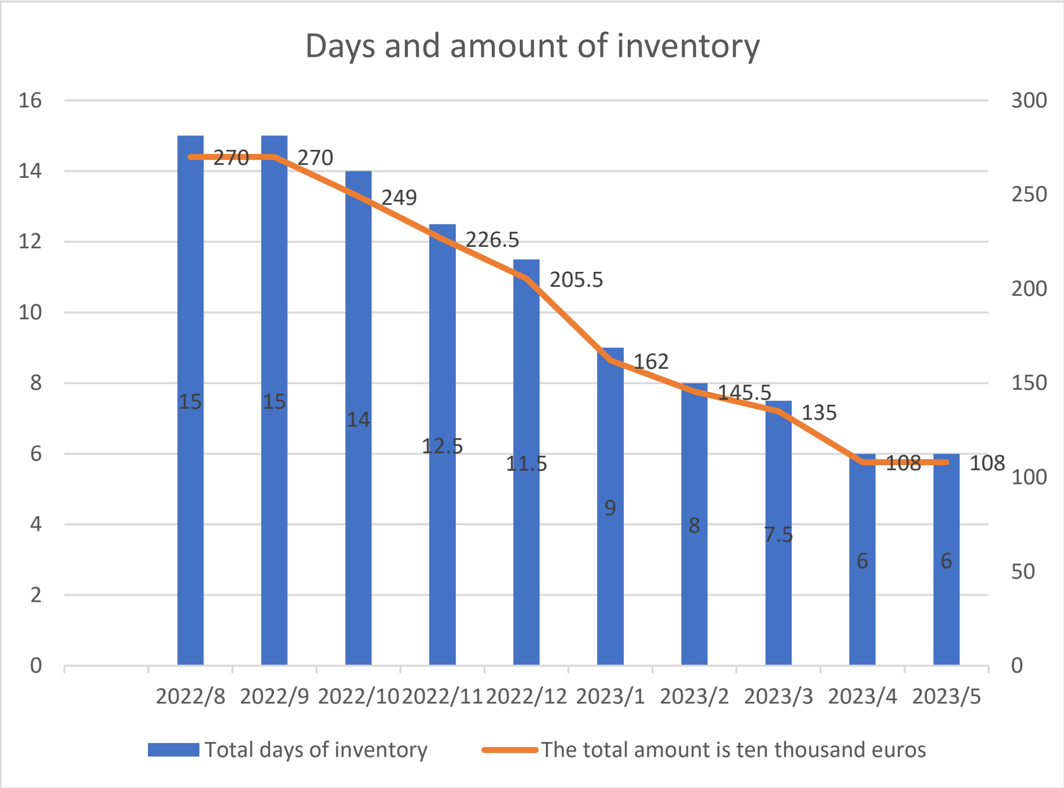


Figure 4.17 Monitoring of inventory days and funds.

# 5. Conclusion and Suggestion

## 5.1 Conclusion

The project was started with the following research question: "How to reduce logistics and inventory costs through lean manufacturing and business process management".

The results of the research will be presented in the following aspects:

1) Identification of important processes related to inventory and logistics costs through the SCOR model.

The impact on inventory and logistics costs was evaluated with reference to the SCOR model, and the final determination was made to use the planning, purchasing, manufacturing, and delivery processes to accomplish the goal.

2) Identify and analyze process issues affecting inventory and logistics costs.

The planning process mainly studied the excessive waste of raw material procurement, the supplier's supply frequency before the improvement was 1 time per week, after the improvement, the supplier's supply frequency was changed to 1 time every 2 days, which made the company's site and inventory capital utilization have been significantly improved, and our results can be seen in the quantitative analysis.

Manufacturing process studied the manufacturing handling waste, process layout workshop transfer, double shift can reduce 2 forklifts and 2 forklift workers. Our results can be seen in the quantitative analysis.

The manufacturing process also studied the manufacturing excess waste, stamping production per batch from 10,000 to 4,000 units, which is expected to reduce the occupied capital by 630,000 Euros and the expected land area by 1,500 $m^2$, you can see our results in the quantitative analysis.

The delivery process studied the problem of inventory waste and pushed the customer to improve the JIT method of picking up goods, the finished goods inventory can be reduced from 6000 sets to 2000 sets, and it is expected to reduce the occupied capital by 140,000 euros, and it is expected to reduce the land area by 330 square meters.

3) Suggestions and measures to improve inventory and logistics costs.

Based on the research of business process identification, process discovery, and qualitative and quantitative analysis of the problem, the final identification of the process re-engineering of raw material ordering cycle, production planning schedule, process layout, delivery cycle, etc. to help solve the problem, and continuous support and monitoring to make it run better.

4) Evaluate the effect of implementation.

According to the operating data for the last 10 months monitored, the inventory days decreased from 14 to 6 and the inventory capital reduced from €2.7 million to €1.08 million, which indicates the positive effect of lean manufacturing and business process management improvements on reducing logistics and inventory costs.

## 5.2 Suggestions

In addition to the improvements in the previous points, it is recommended to continuously promote improvement activities in lean production. The founder of the Toyota Production System, Naiichi Ohno, has already mentioned that waste is divided into seven categories, among which waiting waste is a common phenomenon, mainly due to unbalanced operations, equipment and quality abnormalities that cause people and equipment to wait; this requires researching operation beat statistics to improve operation problems and narrow the gap in operation time; it also requires researching statistical analysis of equipment and quality abnormalities to find the It is also necessary to research the statistical analysis of equipment and quality abnormalities to find the real causes of the problems and implement improvements. Motion waste is another common phenomenon, which is the presence of redundant or unreasonable movements of personnel or equipment in the process of operation, resulting in a slower production pace. Motion waste improvement requires the introduction of specialized motion studies and ergonomic components. Waste reduction is an effective means for companies to improve their business performance and is a long-term activity. In addition to the above types of waste, other improvement activities should be continuously promoted.

In addition, to pay attention to IT technology development and application, ERP system is a widely used and important management tool, is built based on information technology, with systematic management ideas, to provide the decision-making level of enterprises and employees with the means of decision-making operation management platform. WMS system is a software system for managing logistics warehouse. It is mainly used to manage and control the goods in the warehouse to ensure smooth storage and flow of materials. ERP and WMS management systems are essentially systems that store all data related to a company’s business operations in a consistent manner so that all stakeholders who need access to such data can gain such access. Doing so makes it easier to implement changes to business processes.

### 5.3 Limitations

In the context of this study, one of the limitations pertains to its focus on HG Group (a privately-owned enterprise with a 30-year history) as the primary subject of investigation, which precludes an examination of potential variations among other enterprises, particularly those of foreign origin. A second limitation of this study arises from its confinement within the present technological landscape of the automotive industry. It is noteworthy that the influence of technology on management is subject to evolution over disparate temporal phases, yielding divergent outcomes.

In light of the foregoing, this study is posited to proffer innovative insights for prospective enterprises. Nonetheless, it is imperative to acknowledge the necessity of broadening the scope of inquiry in forthcoming research endeavors while concurrently attending to the ramifications of technological advancements.

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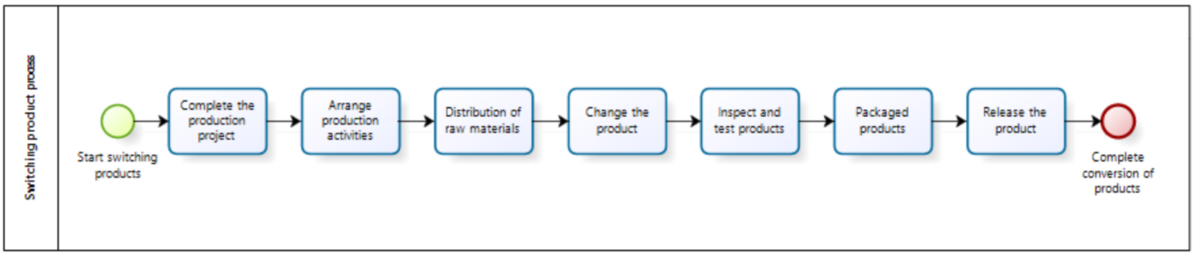
# Annex

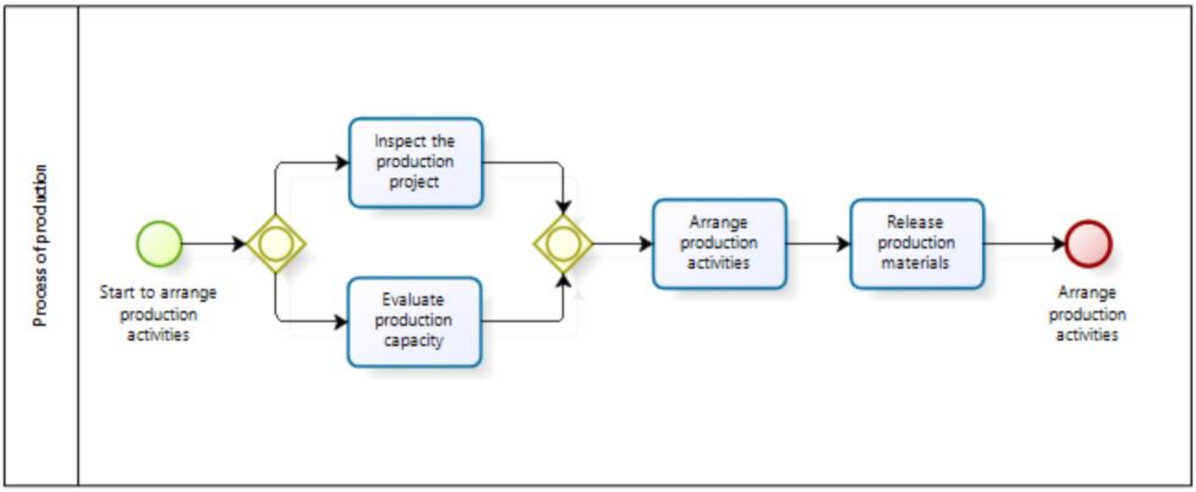
**Annex A**: Stakeholder interviews and field observations

| |
|---|
| 1. What is the company's business process? |
| 2. What are the main wastes of the company? |
| 3. What are the suggestions for reducing logistics costs? |
| 4. What are the suggestions for supply chain improvement? |

**Annex B:** Level 1 product realization process



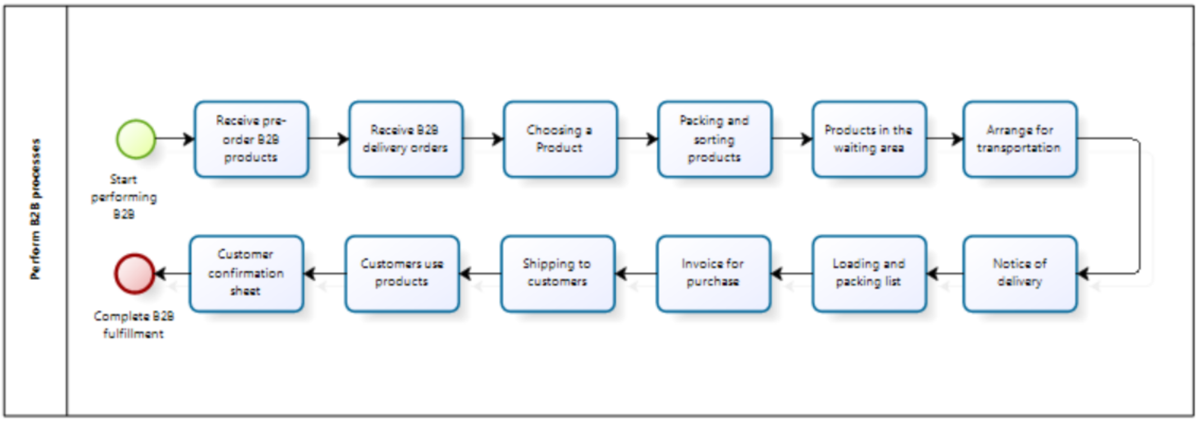

**Annex C:** Production arrangement



**Annex D:** Comparison of quick die change time

| State before improvement | | | | | State before improvement | | | | | Improve the content |
|---|---|---|---|---|---|---|---|---|---|---|
| sequence | Content of work | External work | Internal operation | Accumulation of | sequence | Content of work | External work | Internal operation | Accumulation of | |
| 1 | Lifting of mould | 60 | | | 1 | Lifting of mould | 60 | | | |
| 2 | Work table out | | 5 | 5 | 2 | Work table out | | 4 | 4 | Optimization procedure |
| 3 | Work table moved in | | 5 | 10 | 3 | Work table moved in | | 0 | 4 | |
| 4 | Closure of machine tool | | 2 | 12 | 4 | Closure of machine tool | | 2 | 6 | |
| 5 | Clamping of mould | | 8 | 20 | 5 | Clamping of mould | | 4 | 10 | Change manual to automatic clamping |
| 6 | Adjustment of parameters | | 5 | 25 | 6 | Adjustment of parameters | | 0 | 10 | Modularization of parameters |
| 7 | End pickup switch | 10 | 5 | 30 | 7 | End pickup switch | 5 | 3 | 13 | Prepare the pickup in advance |
| 8 | Confirmation of trajectory | | 5 | 35 | 8 | Confirmation of trajectory | | 0 | 13 | |
| 9 | Cleaning of mould | | 5 | 40 | 9 | Cleaning of mould | 5 | 0 | 13 | Mold cleaning is completed ahead of |
| 10 | inspection | | 5 | 45 | 10 | inspection | | 2 | 15 | Improve mold inclusiveness |
| 11 | Start | | | | 11 | Start | | | 15 | |
| | | 70 | 45 | | | | 70 | 15 | | |

**Annex E:** Level 1 Fulfillment Process Description



**Annex F:** Changes in logistics and inventory costs

| Date | Day delivery | Days in stock | | | Total days of inventory | Amount in stock (ten thousand euros) | | | The total amount is ten thousand euros |
|---|---|---|---|---|---|---|---|---|---|
| | | Raw materials | Semi finished product | Finished product | | Raw materials | Semi finished product | Finished product | |
| 2022/8 | 2000 | 5 | 5 | 5 | 15 | 60 | 105 | 105 | 270 |
| 2022/9 | 2000 | 5 | 5 | 5 | 15 | 60 | 105 | 105 | 270 |
| 2022/10 | 2000 | 5 | 5 | 4 | 14 | 60 | 105 | 84 | 249 |
| 2022/11 | 2000 | 4 | 4.5 | 4 | 12.5 | 48 | 94.5 | 84 | 226.5 |
| 2022/12 | 2000 | 4 | 4.5 | 3 | 11.5 | 48 | 94.5 | 63 | 205.5 |
| 2023/1 | 2000 | 3 | 3 | 3 | 9 | 36 | 63 | 63 | 162 |
| 2023/2 | 2000 | 2.5 | 3 | 2.5 | 8 | 30 | 63 | 52.5 | 145.5 |
| 2023/3 | 2000 | 2.5 | 2.5 | 2.5 | 7.5 | 30 | 52.5 | 52.5 | 135 |
| 2023/4 | 2000 | 2 | 2 | 2 | 6 | 24 | 42 | 42 | 108 |
| 2023/5 | 2000 | 2 | 2 | 2 | 6 | 24 | 42 | 42 | 108 |